Vol 7 Issue 2 2019

HATCHERYFEED

Advances in feeding early life stage and broodstock aquatic species

ADVANCES IN MICRODIETS

Tailored Feed and Tailored Genetics

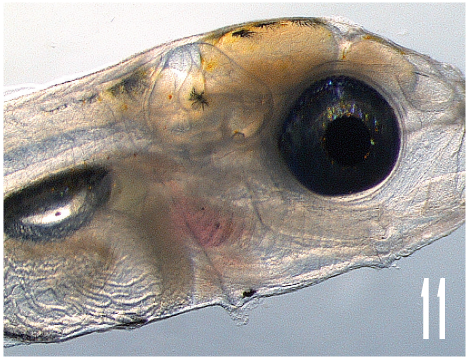
African RAS Tilapia Hatchery

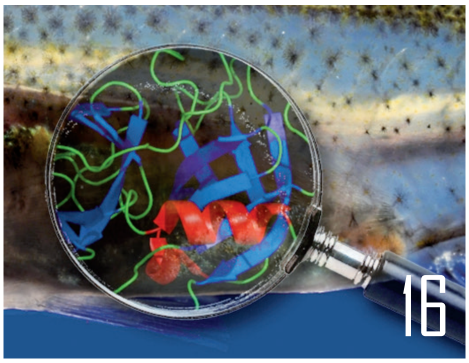
Biofilm, Friend or Foe

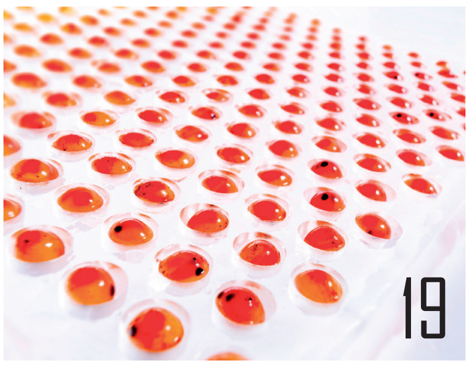
Published by: Aquafeed.com LLC. Kailua, Hawaii 96734, USA www.aquafeed.com info@aquafeed.com

HATCHERYFEED VOL 7 ISSUE 2 2019

Contents







HATCHERYFEED VOL 7 ISSUE 2 2019

We are grateful to the following companies for sponsoring this issue of the magazine. Their support allows us to make our publications available without charge. We thank them for partnering with us to support the development of our industry through education and information.

Index to advertisers

CONTACT US

Editorial:
editor@hatcheryfeed.com

Advertising:
sales@hatcheryfeed.com

Technical feed consulting:
consulting@aquafeed.com

General enquiries:
info@aquafeed.com

DIGITAL & PRINT

Digital editions are free to industry.

Read online, subscribe to receive your issue via email and order print copies at http://hatcheryfeed.com/hatcheryfeed-magazine/

HatcheryFeed
The aquatic hatchery resource from Aquafeed.com

Hatcheryfeed magazine is published by Hatcheryfeed, a division of Aquafeed.com LLC.

Aquafeed.com, LLC.,
Kailua, Hawaii 96734, USA.

www.aquafeed.com
www.hatcheryfeed.com

NEWS REVIEW

HatcheryFeed
The aquatic hatchery resource from Aquafeed.com

Highlights of recent news from Hatcheryfeed.com

News as it happens in the Newsroom at Hatcheryfeed.com - sign up for our free newsletter for monthly updates

Benchmark opens land-based salmon egg production facility

After just over 12 months of construction, Benchmark's new facility, SalmoBreed Salten, has officially opened. The company said that the site is the most advanced land-based facility for the production of salmon eggs in the world. It is located in Sørfold in Northern Norway.

SalmoBreed Salten has the capacity to produce 150 million eggs annually, which is the equivalent of approximately half a million tons of harvested salmon. Malcolm Pye, CEO of Benchmark, said that quality, not just quantity, would be the defining feature of the facility's production – quality guaranteed by both the equipment and the team that the company has assembled.

"The opening of our new facility in Salten is a very important milestone for Benchmark which will allow us to capitalize on our leading market position in salmon genetics and the favorable long-term market trends in the industry," said Jan-Emil Johannessen, Head of Benchmark Genetics.

The company said that producing on land means they are in complete control of the spawning season and thereby, able to supply their customers with high-quality salmon eggs every week of the year, produced in an environment with the highest standards of biosecurity.

Bernaqua hatchery feed certified for organic production

BernAqua achieved the Naturland certification for its organic feed, becoming the first larval feed producer to achieve this certification for larval feed under 300 microns in fish and in shrimps. This adds up to the certification under (EC) 834/2007 and (EC) 889/2008 regulations that the company has recently obtained.

BernAqua becomes a key player on the organic segment producing fish and shrimp feed suitable for use in organic hatcheries with Naturland certification. The company previously earned the latest Belgian and European legislations and is strictly controlled by the Belgian Federal Agency for the Safety of the Food Chain (FAVV-AFSCA).

Every year multiple aquaculture businesses around the world decide to convert to organic production. BernAqua is the first company to introduce an organic feed for shrimp larval stages, Royal Caviar Nature and MeM Nature, as well as an organic feed of sizes below 300 µm for fish larvae, Caviar Nature and MeM Prime Nature, specifically used during the weaning and co-feeding stage.

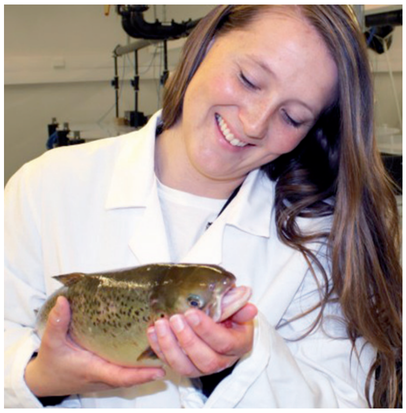
"This new feed will significantly change the way organic fish and shrimp hatcheries operate. Until now, they did not have any similar product allowing them to organically grow fish and shrimp larvae," says Patrick Waty, CEO of BernAqua. BernAqua is convinced that it is an important step towards a bright future of organic fish and shrimp farms. "We are proud that Bern Aqua is actively participating in this transformation," Patrick adds.

Organic production in aquaculture is a production model which supplies animals with specific environment requirements and attaches importance to human health without using any chemicals, pesticides or genetically modified products. Although this alternative production model constitutes only 0.1% of the world's aquaculture production, it is one of the world's fastest growing sectors.

Norwegian researchers develop a method for selecting high feed efficient salmon

Foods of Norway has developed a new method for selecting salmon with higher feed efficiency with the potential to considerably reduce production costs and the environmental footprint of the aquaculture industry. The study was performed in Atlantic salmon for the last 3 years by Food for Norway at the Norwegian University of Life Sciences (NMBU) partnering with AquaGen. Their results open up for directly selecting fish with higher feed efficiency without measuring feed intake.

The assumption was that growth correlates with feed utilization. This is generally true, but growth does not explain everything. The fastest growing fish are not always the most efficient. They may also be the most voracious ones, meaning they make poor use of their feed. In addition to



high feed costs, voracious fish also contribute to a high level of nitrogen and phosphorus excretion in the sea and thus have a negative impact on the environment. Researchers have now successfully documented genetic variations in feed efficiency in Atlantic salmon by measuring the utilization of nutrients from the feed in body tissues. The results show that some fish are indeed more efficient in converting nutrients into muscle, so they are better "body builders".

Researchers said that growth alone can only explain around 60 percent of the variation in feed efficiency. By adding nutrient metabolism to the picture, almost 80 percent of the variation can be explained.

"This new method may enable us to identify parent fish in our breeding population that display a particularly high feed efficiency, allowing us in turn to enhance this trait in the eggs that we sell to our customers," says Senior Scientist in AquaGen and Associate Professor at NMBU, Jørgen Ødegård.

In 2019/2020, Foods of Norway will carry out follow-up studies to validate the method by using rainbow trout and by performing a large-scale experiment with Atlantic salmon in the ocean.

Cooke Aquaculture expanding salmon rearing facilities in Canada

Cooke Aquaculture, supported by the Government of Canada, is expanding its facilities and advancing its existing salmon breeding program. The investments will enable the company to expand its Oak Bay hatchery where it will develop and implement advanced genomics technology, building on its salmon breeding expertise. Government support will also help expand and modernize the company's Johnson Lake hatchery facility, creating up to six new, highly skilled jobs.

Both expansion projects support innovation and productivity improvements in the aquaculture sector and are part of Cooke Aquaculture's five-year plan to invest over $500 million in Atlantic Canada. The Government of Canada is providing contributions of more than $5.6 million to support these projects.

"Our family purchased this hatchery 30 years ago, just a few years after establishing our first salmon farm in Kelly Cove. We invested in a hatchery to ensure we'd have a consistent and independent supply of eggs and smolt. As the company has expanded across the region, so has our need to grow this supply. This facility has continued to play a very important part in our operations and our ability to grow healthy seafood in a safe and sustainable manner," Glenn Cooke, Cooke Aquaculture's CEO, said.

Nofima improvements in farmed cod

Cod is important for the population along the Norwegian coast and having access to a stable supply of cod has always been a dream. Therefore, the Norwegian authorities decided to establish a national breeding program for cod in 2002. The aim was to breed farmed cod that have better growth characteristics than wild cod and that possess higher resistance to fish diseases. Since their start in 2003, Nofima has been working on this national breeding program for cod with their headquarters based at Kraknes just outside Tromsø.

The first year consisted mostly of practical work. “Several of the articles on topics such as egg quality, broodstock nutrition and the development of first-feed have been written in collaboration with industry partners,” says Øyvind Hansen, researcher at Nofima. The researchers have improved disease management, reduced deformities and mortality rate after moving fish to the sea up to 16 percent, which is better compared to farmed salmon.

Today, Nofima grows the fifth generation of farmed cod. Ultrasound technique is used to broodstock sex determination and has become a standard technique. This technique allows cod sex determination without it having to be killed.

Nofima is able to deliver eggs from selected broodstock. When the fry is around 1 to 2 grams, it can be fed in growth facilities. After 21 months in the sea, farmed cods are around three kilos and are ready to be slaughtered.

The improvements that have been made over these 15 years, both in breeding and production, allow cod farmers to have a better starting point regarding their production than they had before. It provides increased production predictability and increased opportunities to achieve profitability within marine-based farming.

Mowi purchases lumpfish hatchery

Mowi has acquired Ocean Matters' aquaculture facility, a hatchery that currently produces lumpfish, one of the two species that have proven to be an effective cleanerfish. The company also cultures ballan wrasse at other facilities.

Ocean Matters produces lumpfish in RAS systems and is the largest producer in the UK and one of the largest world-wide. Mowi has been Ocean Matters' larger customer and collaborator since inception. Dougie Hunter, Head of Cleanerfish and Technical Services at Mowi Scotland, said that this purchase increases the Mowi's capacity for cleanerfish production and it has a great potential for future development.

The use of cleanerfish is now a major part of the company's sea lice control strategy and part of a larger integrated pest management program at its marine salmon farms that includes other non-medicinal sea lice management solutions such as freshwater baths and mechanical removal. Mowi will continue to operate the new purchase under the Ocean Matters name.

Mowi is the world's largest producer of salmon, providing one-fifth of the world's supply. Employing 1300 people in Scotland, the company operates three salmon hatcheries, five freshwater loch sites, 49 sea farms, two processing plants and a feed mill.

Oman plans one of the world's largest microalgae plant

Feed Algae, a UK-based company, plans to build one of the world's largest algae farms in Oman. According to local news, the company plans to invest $440 million in the establishment of the plant that will have the capacity to produce 100,000 tons of algae each year. It is expected that, when the farm is fully running, it will be the largest in the world. The first harvest is expected to be in 2022.

The country environmental conditions are suitable for microalgae production that will be source of proteins and oils for aquafeed, nutrients, fertilizers and more. The farm is will be developed under the Oman's economic diversification plan.

Genetic selection start-up wins Seafood Award

Genetirate, a start-up from the University of Arizona, was honored with the Seafood Innovation Award at the North Atlantic Seafood Forum (NASF) 2019. The company won the honor for its technology for genetic selection to improve sustainability and production.

Genetirate identifies fastest growing embryos through a high-throughput, low-cost test to improve sustainability and production. They use their proprietary diagnostic assay to test various aquatic eggs, embryos, hatchlings and tissues to select aquatic species with greater growth potential and feed efficiency. The company holds the exclusive license to the first patented pending technology that allows

for quantitative high-throughput measurement of metabolic rate to select individual aquatic animals with improved feed efficiency and growth rate.

GenetiRate was founded on a technology invented by Benjamin Renquist, assistant professor of animal and comparative biomedical sciences at the UA College of Agriculture & Life Sciences. With the leadership from their CEO, Chaz Shelton, GenetiRate has grown from a technology into a company. "We are excited to receive a warm welcome from the aquaculture industry," Renquist said, "and appreciate that they value a technology developed here in the desert."

The annual NASF competition aims to stimulate and recognize knowledge-based innovation and entrepreneurship in the industry. GenetiRate is also hoping to increase its profile joining the next cohort of Hatch. "We want to become a billion dollar company and go international – by joining Hatch, in three months we can get exposure across the entire world. It's the perfect platform," says Shelton.

Mexico opens first shrimp genetic research center

The Mexican National Commission of Aquaculture and Fisheries (CONAPESCA) has inaugurated the Genetics Unit of the Biosecurity Masal Selection of Mexican Aquaculture Genetics (Genamex), which will produce high-quality, certified shrimp broodstock and will supply larvae production laboratories at nationwide to improve the performance of shrimp production.

The new facility is the result of the combined efforts of Sinaloa aquaculture producers and the support of the authorities of the sector. CONAPESCA authorities said that this unit will set a precedent for the strengthening of the national aquaculture sector and consolidates an alliance with shrimp farmers for the development of the production of quality and disease-free shrimp postlarvae.

Microdiet technology can contribute towards a high live-prey replacement strategy in first feeding gilthead seabream

Wilson Pinto[1], **Sofia Engrola**[2], **Bruno Nunes**[1,3], **André Santos**[1] and **Luís Conceição**[1]
[1]Sparos Lda., [2]Center of Marine Sciences of Algarve (CCMAR), [3]Instituto Politécnico de Beja, Portugal

Figure. 1. Two-month old gilthead seabream (*Sparus aurata*) larvae.

Gilthead seabream (*Sparus aurata*) is a dominant species in Mediterranean fish farming. During the first 30 days after hatching (DAH), seabream is particularly fragile, exclusively depending on live-prey. Due to their narrow mouth gap, larvae are fed on rotifers during the first two weeks, with Artemia supporting larval development until weaning onto microdiets, which normally occurs during the second month of life (Fig. 1). Considering this reality, it is a goal for aquafeed companies to produce a microdiet able to sustain growth and development of seabream during the first month of development.

An early replacement of live-prey by microdiets would bring obvious benefits for seabream hatcheries: increasing production predictability, saving on operational costs related to live-prey production chain, reducing the introduction of pathogens in larval tanks, among others. However, during the first weeks of

Over the last decade, a significant evolution occurred in the quality of commercial microdiets, mostly due to an increasing knowledge on larval nutrition, production technologies and availability of highly-digestible ingredients. Largely contributing to such progress is the inclusion of protein hydrolysates, the resulting products of an enzymatic digestion of proteins.

development, the preying ability and digestive capacity of seabream are extremely limited. The onset of exogenous feeding (first-feeding) is particularly critical since larvae possess a functional but undifferentiated digestive tract, composed by a presumptive stomach (Sarasquete *et al*., 1995). The absence of a fully developed stomach results in the lack of acidic digestion, hindering digestion of complex protein found in microdiet particles.

Improving microdiet technology for an adequate nutrient delivery to first-feeding larvae

Over the last decade, a significant evolution occurred in the quality of commercial microdiets, mostly due to an increasing knowledge on larval nutrition, production technologies and availability of highly-digestible ingredients. Largely contributing to such progress is the inclusion of protein hydrolysates, the resulting products of an enzymatic digestion of proteins. The source of protein and degree of hydrolysis determine the amino acid and peptide molecular profile of the hydrolysates, resulting in different compositions of oligopeptides, tri/dipeptides and free amino acids. This

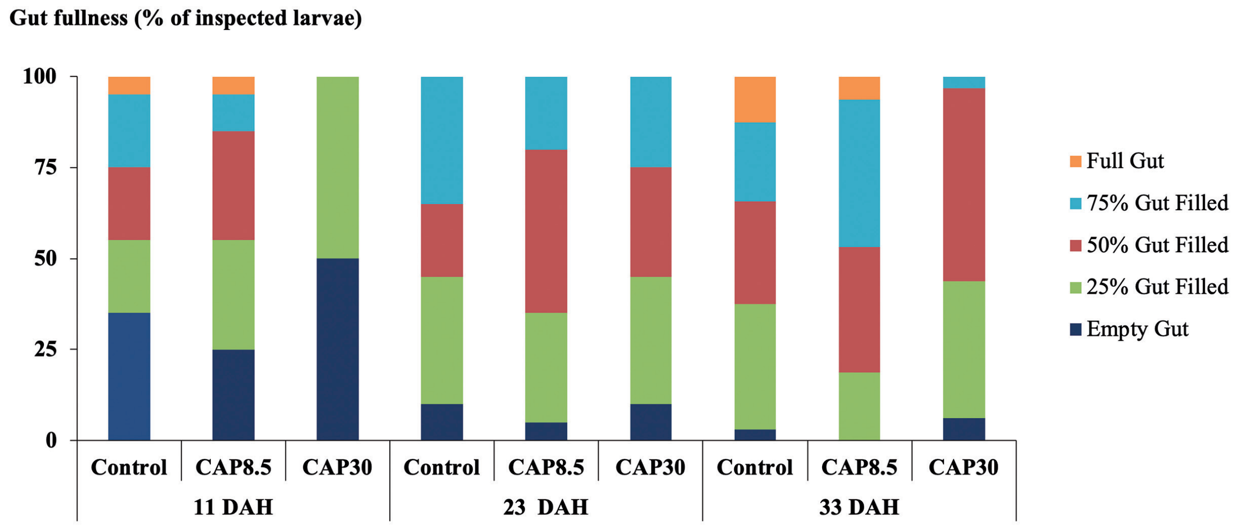


Figure 2. Percentage of gut filled with microparticles at several ages of seabream fed experimental microdiets from first-feeding onwards with a high live-prey replacement.

variability increases the research opportunity to explore the biological potential of these ingredients, especially because some offer not only nutritional value but also bioactive properties. Although there is still a large avenue to explore, it is very clear that these nutrients need to be maintained within microdiet particles to be effectively delivered to the larvae. However, the diameter of microdiet particles for first-feeding larvae, namely seabream, should be around 100 µm. This small diameter largely increases the particle surface-to-volume ratio, exposing the microparticle core into the surrounding water and promoting losses of water-soluble protein, a process entitled leaching. Protein leaching from microdiets is affected, amongst other factors, by particle size, production technology and protein complexity. It may result in losses up to 50% in just a few minutes following microdiet immersion, reducing its nutritional value and contributing for a degradation of water quality.

Most commercial microdiets are produced by extrusion, a process where a mash of ingredients is pushed through a dye of known cross-section. Yet, current extrusion technologies only allow a direct production of pellets around 800 µm at a fast rate. Therefore, pellets are normally extruded at a larger size, following crumbling or spheronization, processes that may disrupt the outer layer of microparticles and increase leaching of water-soluble protein. An additional technology that may allow preserving these nutrients inside microdiet particles is microencapsulation, a process where nutrients are enveloped on a polymeric carrier. With this in mind, and under the scope of project "FEEDFIRST: development of a new technology for fish larvae at first feeding", SPAROS (Olhão, Portugal) developed a microencapsulated prototype able to reduce leaching of a protein hydrolysate commonly used in microdiets for fish larvae. This prototype was able to prevent around 75% of leaching of water-soluble protein following 2 hours of immersion, a significant achievement when considering the hydrolysate is 100% water-soluble.

Biological efficacy of a novel microencapsulated prototype in first-feeding seabream

Joining efforts with the Centre of Marine Sciences (Faro, Portugal), SPAROS Lda. evaluated the biological efficacy of the novel microencapsulated prototype in first feeding seabream larvae. For this purpose, a commercial microdiet was used as an experimental control, whereas the novel prototype was added to the formulation of this commercial microdiet at two inclusion levels: 8.5% (CAP8.5) and 30% (CAP30). All microdiets were fed to gilthead seabream from first-feeding (3 DAH) until the 34 DAH (end of the experiment). Microdiets were offered close to satiation during the experimental period, being co-fed with

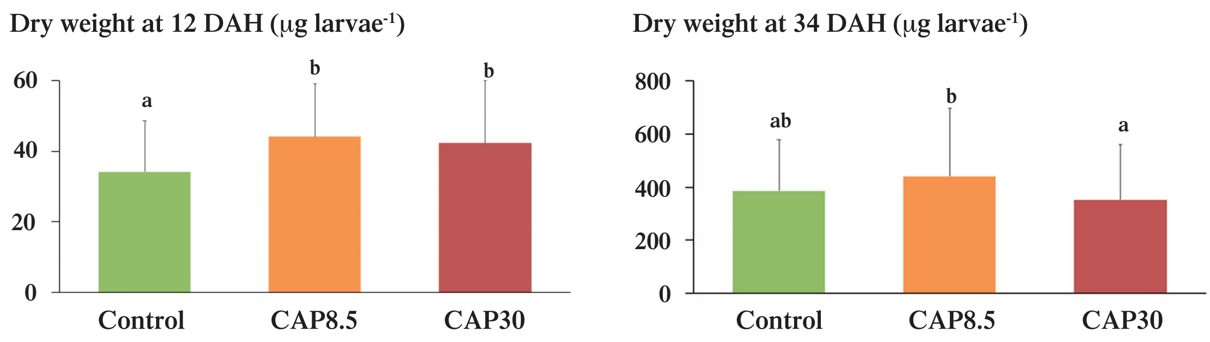


Figure 3. Dry weight of seabream (12 DAH – left; 34 DAH – right) fed experimental microdiets from first-feeding onwards with a high live-prey replacement.

... high dietary protein hydrolysate levels may not be adequate for seabream following the first two weeks of development.

enriched rotifers from 3 to 13 DAH. In comparison to a standard feeding regime, the quantity of rotifers was initially reduced by 20% in all treatments. Rotifers provided to the rearing tanks gradually decreased from 40 to 85% of usual rotifer quantities from 7 to 13 DAH, respectively. A residual amount (0.3 nauplii/mL) of Artemia AF strain was maintained in the rearing tanks from 12 to 23 DAH, with larvae feeding solely on the microdiets from 24 to 34 DAH. The experiment was performed in 100 L conical-cylindrical fiberglass tanks where all treatments were tested in quadruplicate, using an initial density of 120 larvae L^{-1}. Larvae were regularly sampled during the experimental period to assess the percentage of digestive tract filled with microdiet particles (visual inspection) and growth performance. At the end of the experiment all larvae were counted to determine survival.

Results

At the end of the experiment, no significant differences were detected on larval survival, ranging between 4 and 7 % in all treatments, values considered acceptable for seabream reared in low-volume tanks. Furthermore, the visual inspection performed to the larval digestive tracts showed that seabream readily ingested microdiet particles during the first days of feeding, which increased with larval development (Fig. 2). Larvae from the treatments where the new microencapsulated prototype was offered had a significantly higher weight (ranging 20-23 % more) at 12 DAH than larvae from the Control treatment (Fig. 3, left). However, at the end of the trial, larvae from the CAP30 treatment did not maintain a high growth performance, having a significantly lower dry weight than larvae from the CAP8.5 treatment (Fig. 3, right). Interestingly, these results were apparently correlated with microdiet ingestion, a lower pattern was also observed in larvae from the CAP30 treatment at the end of the trial.

Findings from the current study suggest that high dietary protein hydrolysate levels may not be adequate for seabream following the first two weeks of development, in agreement with previous observations by Canada *et al.*, (2017) for Senegalese sole (*Solea senegalensis*). Moreover, the overall growth performance of seabream larvae in the current experiment attained similar values to those considered normal by Mata-Sotres *et al.*, (2016) for seabream fed on live-prey only. These findings are extremely interesting, particularly when considering the feeding strategy with a high live-prey replacement ratio used, suggesting that an earlier weaning with high live-feed replacement during the first weeks of seabream development may be regarded as a future step to seabream hatcheries.

Future trends

The room for improvement in commercial microdiets for first-feeding larvae is apparently large, in terms of formulation, through the use of emerging highly digestible ingredients and microencapsulation technology. For the production of smaller microdiet microparticles this technology is very promising. Yet, although microdiet quality is expected to increase in years to come, a strong effort should also be addressed towards the optimization of feeding protocols, both in terms of microdiet quantities and feeding frequencies, as these may have a key role in determining success in larval rearing upon an early weaning. An earlier introduction of microdiets in the feeding regime will also contribute to increase knowledge of fish larvae requirements, sustaining an optimal nutrition during the early life-stages of fish. When successful at a commercial level, an earlier weaning will help defining a higher juvenile quality, leading to shorter production cycles and leveraging a further expansion of the aquaculture industry.

References

Canada P, Conceição LEC, Mira S, Teodósio R, Fernandes JMO, Barrios C, Millán F, Pedroche J, Valente LMP, Engrola S. 2017. Dietary protein complexity modulates growth, protein utilization and the expression of protein digestion-related genes in Senegalese sole larvae. *Aquaculture 479, 273-284*.

Mata-Sotres JA, Martos-Sitcha JA, Astola A, Yúfera M, Martínez-Rodríguez G. 2016. Cloning and molecular ontogeny of digestive enzymes in fed and food-deprived developing gilthead seabream (*Sparus aurata*) larvae. *Comp Biochem Phys B 191, 53-65*.

Sarasquete MC, Polo A, Yúfera M. 1995. Histology and histochemistry of the development of the digestive system of larval gilthead seabream, *Sparus aurata* L. *Aquaculture 130, 79-92*.

More information:

Wilson Pinto Ph.D.
SPAROS Lda., Portugal
E: wilsonpinto@sparos.pt

Molofeed – a Norwegian start-up with the aim to substitute live feed for fish and shrimp larvae

Ingmar Hogoy and **Bernd Ueberschär,** Molofeed

One of the main challenges in global aquaculture is to improve larval production of marine fish and shrimp by reducing dependency on live feed. The standard live feed organisms, rotifers and brine shrimp, have naturally occurring nutritional deficiencies and the production is both costly and labor intensive.

Figure 1. Microdiets can come in a wide variety of compositions, which make the color and structure.

Moreover, looking at *Artemia* cysts harvested over the last 25 years, even in periods with favorable conditions, the natural production hovers around 3,000 tons per year. Most of these harvested cysts with reasonable quality are consumed every year by today's aquaculture industry and the consequences for the growing sector of marine aquaculture are underestimated. According to the forecasts by FAO and other entities, the production of marine fish and shrimp is expected to double during the next 15 to 20 years and

Figure 2. One of the most important goals in relation to formulated larval feed is to avoid skeletal malformations. These malformations can be made visible in a biochemical procedure including a staining process of bones and cartilages (picture shows seabass larvae with normal spine).

obviously such growth can only be realized when more fry can be produced with fewer Artemia.

Microdiets, that mimic the composition of the natural food organisms for marine fish and shrimp larvae such as the nauplii stages of calanoid or harpacticoid copepods, may be a perfect replacement for the sub-optimal standard live diet and would omit the high effort required to produce live feed in hatcheries. Replacing the laborious live feed production facilities with high quality microdiets will greatly simplify marine larval production, improve hatchery consistency and help reduce the cost of fry production.

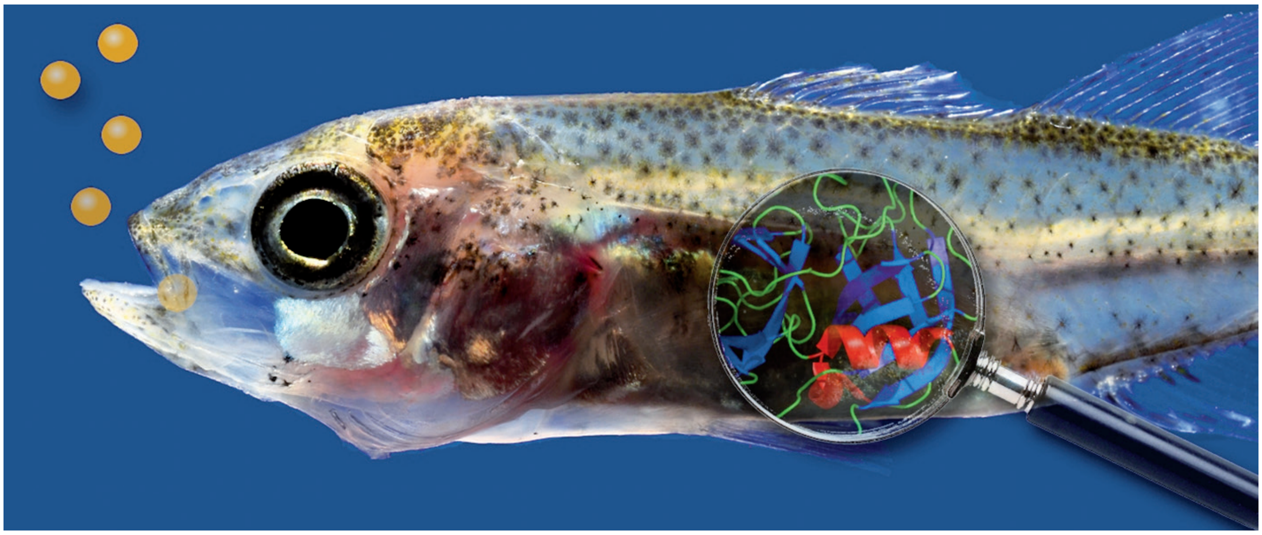
Interestingly, one of the criteria for successful salmon farming that began in Norway around 1970 was the relatively simple fry production. Salmon larvae are able to accept formulated feed as first diet, yielding survival rates of up to 90%. For marine species, this process was much more complex. The eggs and larvae are extremely small and must be fed with live feed like rotifers and *Artemia* in the early life stages. The first attempts to feed marine fish larvae with formulated feed in the '70s and '80s were far from successful and it was several decades before products were made available that could be seriously considered at least as partial replacement of live feed. Nevertheless, microdiets have now evolved into high-tech products and the advances achieved in the quality in the past 5-10 years are exciting.

The Molofeed products use a specific and patented microencapsulation technology resulting in the potential to replace live feed on a significant level and excellent technical quality of the product.

New generation of microencapsulated feed

Molofeed, founded in 2015 by Ingmar Høgøy, was involved in this process. After years of research in developing a new microencapsulation technology and improving recipes together with scientists, a new generation of microdiets for shrimp and fish larvae is ready for the market.

Most of the feeds currently available are microbound, where the components of the feed are held together by a binder that forms a network with the different ingredients. This technology has some weaknesses, specifically quick leaching of water-soluble components and deterioration of water quality. The Molofeed products use a specific and patented



microencapsulation technology resulting in the potential to replace live feed on a significant level and excellent technical quality of the product.

Looking back at history, during the '90s the founder of Molofeed, Ingmar Høgøy, became involved with several projects for improving the utilization of by-products from the fishery and salmon industries. One of the technologies applied was the hydrolyzation of fish proteins. The potential of pre-digested proteins as a major component of microparticulate larval feed was an up-and-coming topic in fish larval nutrition at that time. A new avenue for the development of microparticulate larval feed was opened and a suitable technology was established for capsulation of the water-soluble ingredients in formulated feed for marine fish and shrimp larvae. These achievements were the groundwork for the establishment of Molofeed in 2015.

Aqua-Spark partnership

In 2016, Ingmar Høgøy participated in the Angel Challenge competition with a concept named "baby food for baby fish" and after being awarded the winner of the competition, he received funding from Norwegian investors to set up a pilot plant for further development of the concept. By using remaining raw materials from the Norwegian fish farming and fishery industries, Molofeed has access to high quality marine proteins for the sustainable production of marine larval feed at reasonable costs, which is an important aspect in consideration of live feed replacement and reduced costs in fry production.

All of this matches well with the philosophy of Aqua-Spark, a global investment fund based in Utrecht, The Netherlands that makes investments in sustainable aquaculture businesses that generate investment returns, while creating positive social and environmental impact. The Molofeed team is happy to have Aqua-Spark on board as an investor to facilitate the further development and global expansion of the company. Aqua-Spark and Molofeed have the same overarching goal of growing sustainable aquaculture production. The production of more food for a growing population is one of the global challenges and sustainable aquaculture is an important part of the solution.

Images: Dr. Bernd Ueberschär

More information:

Ingmar Hogoy
Founder of Molofeed
Molofeed
E: Ingmar.hogoy@minipro.no

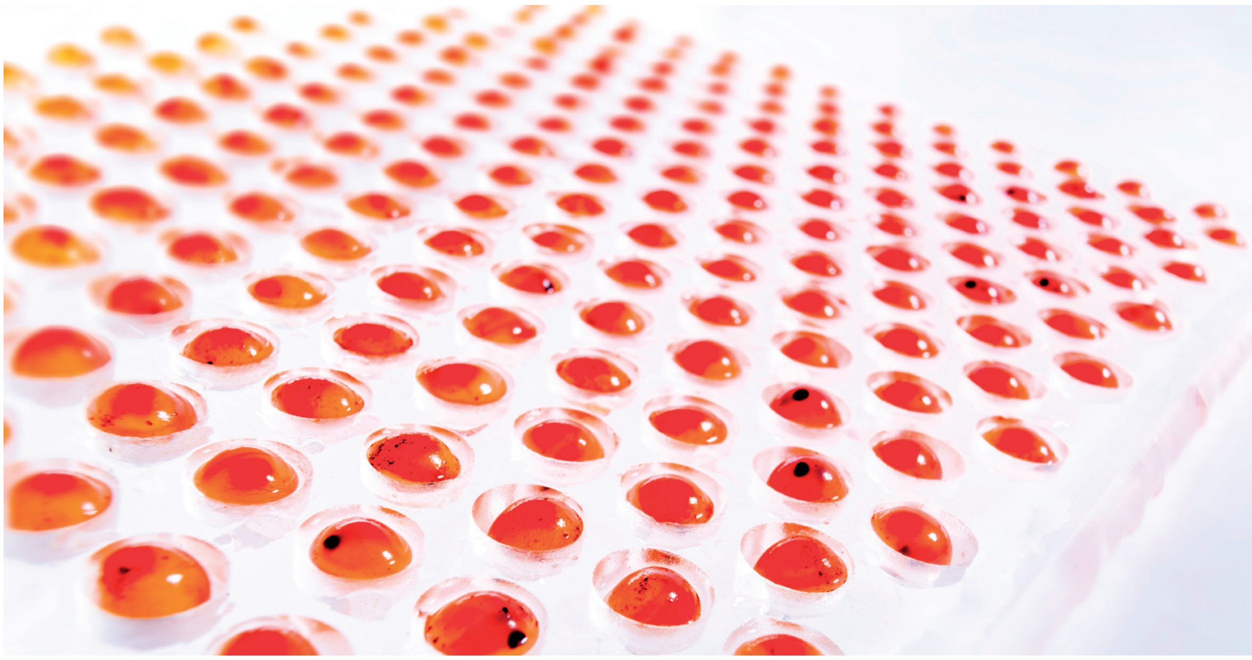
More information:

Dr. Bernd Ueberschär
Senior Scientist
GMA – Gesellschaft
für marine Aquakultur
E: ueberschaer@gma-buesum.de

Tailored feed, tailored genetics

Robbert Blonk, Hendrix Genetics Aquaculture

Hendrix Genetics brings genetics and feed optimization together. Obtaining optimum performance of production stock is not just a matter of applying the right management, feed or genetics, but rather a combination of the three together and it is important to take into account interactions. The multi-species breeding company Hendrix Genetics aims to provide producers with the right strains by carefully fine-tuning selections keeping in mind the other actors in production. Recent trials by Hendrix Genetics R&D show that choosing the right strain and diet, and/or environment is essential to obtain optimum results.



Towards optimization in the aquaculture value chain

The globally increasing professionalization of aquaculture results in optimization of shackles in the value chain. With this optimization we see a strong move towards specialization of shackles, often in combination with consolidation. This movement is seen in the entire supply chain, including breeding and feed companies.

Hendrix Genetics is a Netherlands based breeding company with roots dating back to 1923. Starting off with basic selection programs in layer poultry, the company quickly developed its current state by embracing the rapid development of breeding technology. Being a multi-species breeding company, Hendrix Genetics now develops and uses state of the art genetic selection tools for its genetic lines for layer poultry, swine, turkeys, colored broilers, salmonids and shrimp. For all species, different products are produced, each tailor made to specific customer needs.

Similarly, research and development departments of the major feed companies are devoted to bring the aquaculture industry to a next level by manufacturing ever better fish feeds. For example, replacement of fish meal and oil with plant and algae-

... maximizing productivity by only adjusting feed may not be very effective if the environment or the genetic strain used are not complementary.

based ingredients, but also insect-based products are getting more interest every day. Functional feeds are getting a place in farm practices more and more. Everything aimed at optimization of the nutritional side of animal production.

A one-sided view compromises results

In this article we show that a one-sided view on optimization of aquaculture production is compromising economic results. For example, maximizing productivity by only adjusting feed may not be very effective if the environment or the genetic strain used are not complementary. One reason for this is the existence of so-called genotype by environment (GxE), or genotype by diet (GxD) interactions, simply meaning that ranking of animals on breeding values depends on the environment or diet - with a breeding value meaning the expected genetic contribution that an animal transmits to its offspring. This implies that different environments or diets may favor animals of different genetic makeup, i.e. different genetic lines. For example: a plant-based diet may only yield optimal production results when a tailor made, plant ingredient tolerant strain is used. GxE or GxD interactions are typically expressed in genetic correlations, with high correlations (0.7 and higher) suggesting little reranking of animals, and low correlations suggesting high reranking across environments or diets. Several examples of interactions have been published in literature (Mas-Muñoz *et al*. 2013, Nguyen *et al*., 2017).

Though commercial implications of GxE or GxD interactions will differ case by case, recent trials by Hendrix Genetics R&D in Chile supported by literature, show that in quite some cases, choosing the right

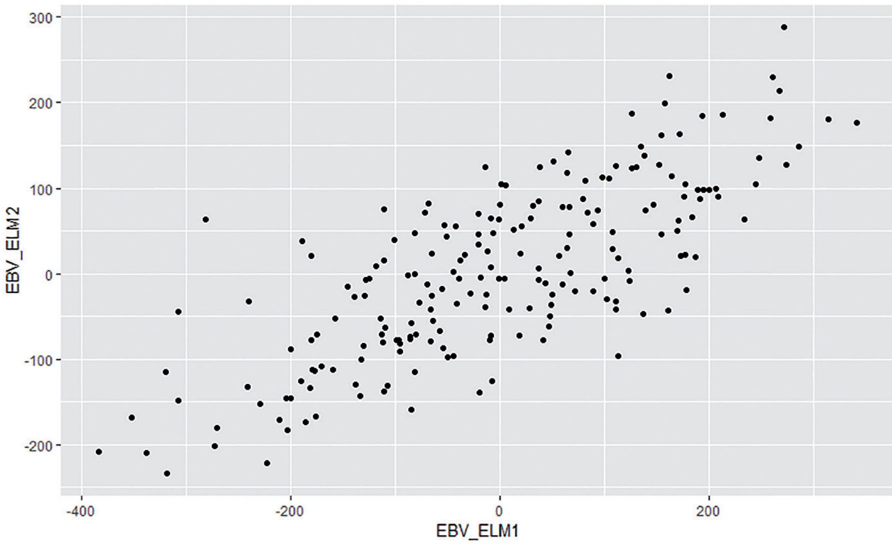


Figure 1. Plot with genetic correlations between two production environments for trout showing GxE interaction. The genetic correlation between environments was 0.7. It is clear that the best families in the one environment are not per se the best families in the other environment. The effect becomes stronger once correlations are lower.

strain and diet, and/or environment is essential to obtain optimum results.

Interactions affect production

Over the past few years, governmental regulations in Chile have triggered salmon farmers to expand southwards to the Magallanes region (region XII) and it is highly likely that the majority of expansion of Chilean production will be placed in this area. However, the environmental characteristics between the different culture regions differ substantially, with extreme changing photoperiod, and colder and less saline waters in the more southern areas. To be able to provide Chilean salmon companies with optimal production stock, Hendrix Genetics investigated GxE interactions for the Chilean family program for Atlantic salmon. To this end, genetic performance of different families in region XI and region XII was analyzed using so-called sentinels. Sentinels form a key part of the genetic program of Hendrix Genetics in Chile to monitor and optimize performance in growth, survival and processing of families under commercial environments.

The genetic correlations measured across the two regions indicated strong GxE interactions for harvest traits with values as low as -0.16 ± 0.006 for harvest weight. For the other harvest traits, including color and fillet yield, also significant and strong GxE interactions were found. This indicates strong reranking of families between regions implying that for optimal salmon production in region XII, fish should be selected based on performance data specifically from region XII and not from region XI, and vice versa. To make implications more tangible, one can look at the effect of selection on expected improvement of growth: with selection of the 10% best families based on production data in region XII, around 0.8 kg or more genetic gain is expected in region XII compared to when one bases selections on production data from region XI. Hendrix Genetics currently has multiple sentinel groups in different locations in Chile and separate products are produced for different regions and needs in the market.

Similar trials with the Hendrix Genetics' Kona Bay soy tolerant strain of whiteleg shrimp show 24% faster growth on soy diets compared to regular shrimp diets based on fish meal. Conversely, shrimp selected for growth on regular diets thrive less on diets with a high level of soy. Varying interactions were reported for rainbow trout and European seabass when animals were subjected to plant-based diets instead of regular fishmeal-based diets (Le Boucher *et al.*, 2011 a and b). Recently, a production trial was set up at Hendrix Genetics' Troutlodge facilities to test for interactions across different production environments. The environments were mainly characterized by low temperature, high oxygen levels, and high water quality vs high temperatures, lower oxygen levels, and lower water quality. GxE interactions of around 0.7 were found (Fig. 1), while published results on the same populations showed much stronger significant interactions in extremer Peruvian, German and North American environments (Sae-Lim *et al.*, 2013), implying room for optimization of strains per environment or vice versa.

Precision farming needs precision feeding, and breeding!

Professionalization of aquaculture is speeding up and is spreading across species, beyond salmon farming. Professionalization comes with optimization, and as part of this, precision farming is expected to become a reality for the more advanced aquaculture sectors in the near future. At individual level, feeding and breeding companies push everything to get maximum use out of their product development and their products. However, making the right match is crucial. Both Hendrix Genetics' trials and peer reviewed literature show the relevance of interactions between genotypes and feeds or environments. With the current results it is to be expected that in the very near future even subtle differences in environments, feeds and optimal stocks, and especially the right match between them will make the difference for a successful aquaculture business.

References

Le Boucher R, Quillet E, Vandeputte M, Michel Lecalvez J, Goardon L, Chatain B, Médale F and Dupont-Nivet M. 2011a. Plant-based diet in rainbow trout (*Oncorhynchus mykiss Walbaum*): Are there genotype-diet interactions for main production traits when fish are fed marine vs. plant-based diets from the first meal? *Aquaculture, Volume 321*.

Le Boucher R, Vandeputte M, Dupont-Nivet M, Quillet E, Mazurais D, Robin J, Vergnet A, Médale F, Kaushik S, Chatain B. 2011b. A first insight into genotype × diet interactions in European sea bass (*Dicentrarchus labrax* L. 1756) in the context of plant-based diet use. *Aquaculture Research, Volume 42*.

Nguyen NH, Hamzah A, Thoa NP. 2017. Effects of genotype by environment interaction on genetic gain and genetic parameter estimates in red tilapia (*Oreochromis spp.*). *Frontiers in Genetics, 8:82*.

Mas-Muñoz J, Blonk RJW, Schrama JW, Arendonk J, Komen H. 2013. Genotype by environment interaction for growth of sole (*Solea solea*) reared in an intensive aquaculture system and in a semi-natural environment. *Aquaculture, Volume 410*.

Sae-Lim P, Kause A, Mulder HA, Martin KE, Barfoot AJ, Parsons JE, Davidson J, Rexroad CE, Arendonk van JAM, Komen H. 2013. Genotype-by-environment interaction of growth traits in rainbow trout (*Oncorhynchus mykiss*): A continental scale study. *Journal of Animal Science, Volume 91*.

More information:

Robbert Blonk
Director of Research
and Development
Hendrix Genetics Aquaculture B.V.
E: robbert.blonk@hendrix-genetics.com

Fry quality and latent effects in fish grow-out: no second chance for a first good start

Alessandro Moretti, INVE Aquaculture

European seabass and gilthead seabream are the backbone of Mediterranean finfish aquaculture. While both species account for 12% of total aquaculture production in the European Union (T live weight), they alone represent 22% of the whole production value1. Despite the overall revenue of European seabass and seabream aquaculture which has been increasing in the recent years, their production is no longer experiencing a pronounced increase, particularly in the Mediterranean.

Both European seabass and gilthead seabream display a complex larval development which requires specialized rearing systems, fine-tuned protocols, premium feeds, and highly skilled staff. At present, hatcheries have reached a relative stability in the fine tuning of efficient culture protocols and are now encouraged to produce fry that result in high-quality specimens up to the farm gate. Favoring quality over quantity is unquestionably the most economic and environmentally sustainable approach of aquaculture producers willing to participate in the ongoing Blue Revolution.

Bottlenecks in Mediterranean fish farming

The European seabass and gilthead seabream show a complex lifecycle (Fig. 1), which has been, and still is, a bottleneck to upscale production. Broodstock selection plays a pivotal role in the production of offspring with optimal genetic traits. Larviculture protocols must guarantee that larvae are exposed to optimal conditions, in order to exploit their genetic potential to its full extent and give origin to premium fry and juveniles that are more resilient and that are able to rapidly attain commercial size during grow-out.

Parental investment is often determined by broodstock genetic quality, husbandry practices and nutrition, whereas larval quality and juvenile development are mostly determined by rearing technology, environmental settings and nutrition (Fig. 1). All these factors are paramount in an interconnected manner to secure a premium performance during grow-out. Maximum fish farming performance can only be safeguarded if fry quality potential is totally expressed and acknowledged as the basic start to secure performances during grow-out. Fry must be perceived as finely tuned machines that are programmed to turn feed energetic input into biomass. The more accurate the match between feed quality and fry energetic demand, the better is the capacity to fully explore the fry genetic potential to grow faster and to be more resilient.

Success relies on the combined genetic potential, rearing technology and nutrition

Suboptimal rearing conditions and feeding experienced by fry and juveniles will ultimately promote suboptimal growth performances. Overall, the history of fish early life can be carried-over to later stages and only be detected when these are already juveniles or young adults (O'Connor *et al.*, 2014).

Just as hatching or any other dramatic shift in a species life stage are not new beginnings that reset embryonic or larval history (Pechenik, 2006), respectively, entrance at the farm gate will not reset the conditions experienced during larval and juvenile stages. Indeed, even when placed under optimal conditions and fed premium feeds during grow-

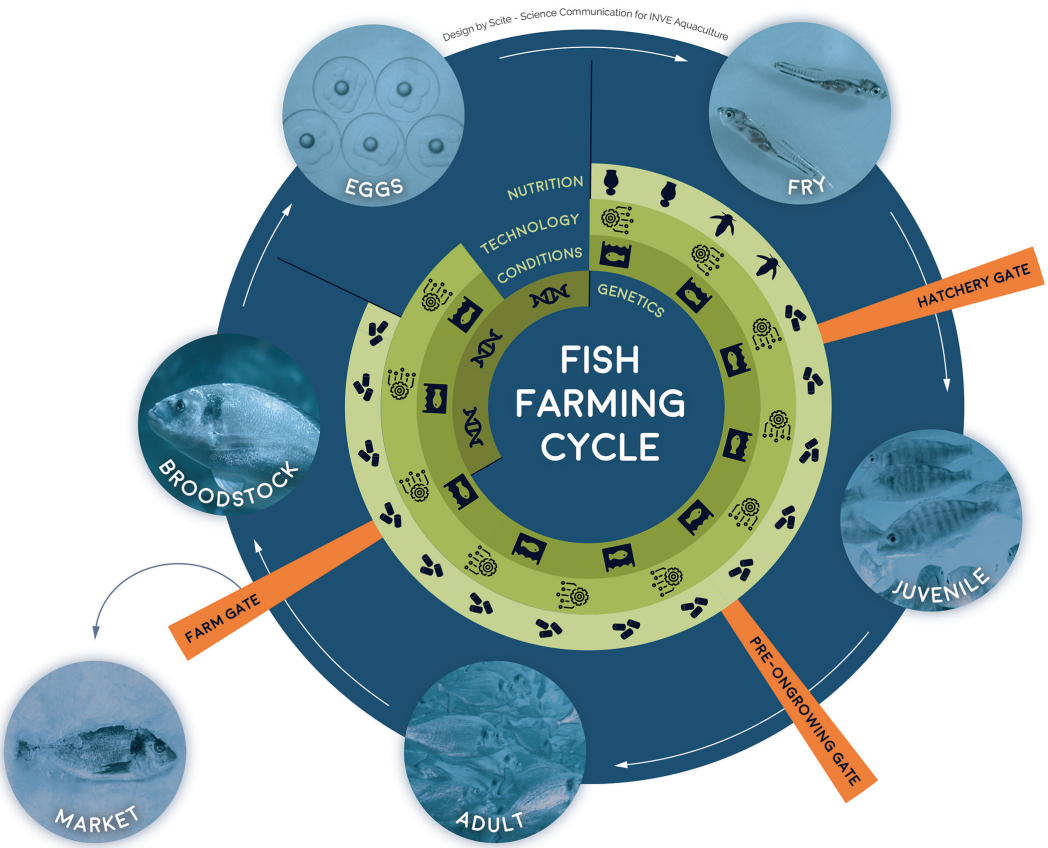


Figure 1. Fish farming cycle highlighting the relevance of genetics, husbandry conditions, rearing technologies and nutrition along different life stages of fish. Hatchery and farm gates are common checkpoints that mark transition between facilities.

out, juvenile fish that have experienced suboptimal conditions earlier in their lifecycle, particularly in the hatchery or during pre on-growing phases, will likely fail to perform as expected.

Good genes are particularly important for species like seabass and seabream that have a relatively fragile larval life. However, good genes do not impair latent effects if hatchery and pre-on-growing practices are not top levelled. Hatcheries and pre on-growing units must rise up to the challenge of producing and achieving consistent and higher standards of quality so European seabass and gilthead seabream are able to excel throughout their whole productive cycle: from hatching to harvesting. In modern aquaculture, performances at hatchery and farm gates can no longer be perceived decoupled. Beyond farm gate, there is no second chance for a first good start.

Setting new standards in fish farming

If premium juvenile and adult performance are not possible because fish have been exposed to suboptimal conditions in the hatchery, can hatcheries screen for latent effects? This is far from being an easy task. At the farm gate, producers often target features which may not be the most suitable proxies to identify the best fish grow-out performance. For instance, one can refer to behavioral or morphological traits of juvenile fish, such as size or deformities, when grading specimens that will be used to stock a cage. These features are useful but not enough to truly identify fish growth potential. For instance, larger juveniles are often selected positively over smaller ones. However, if no information is available on fry performance at the hatchery, larger specimens may not be the ones displaying the best performances during grow-out. The conditions experienced in larval life often generate an energetic burden that remains latent until later stages of the fish life cycle that must be identified and tackled at the hatchery.

It is critical that detailed information on the life history of juvenile fish is available prior to entering the farm gate. Project FRY 2.0 by INVE Aquaculture (Fig. 2) is

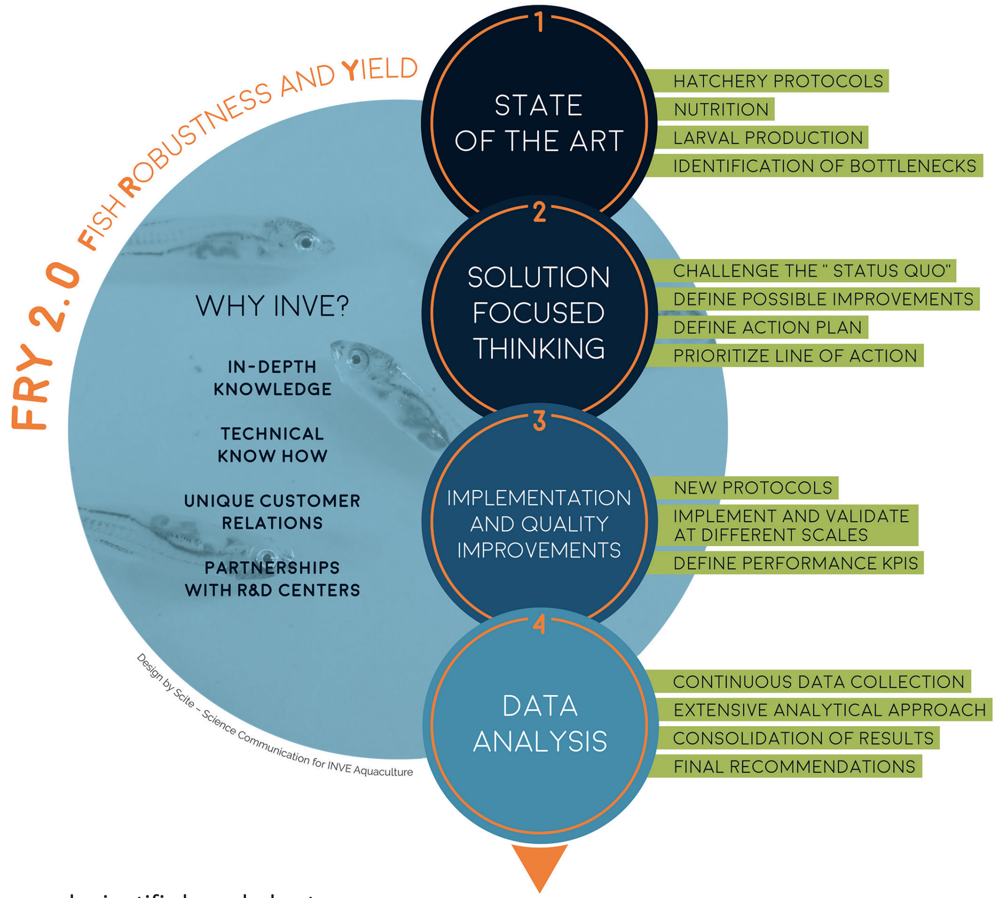


Figure 2. Outline of Fish Robustness and Yield (FRY) 2.0 project promoted by INVE Aquaculture to critically access the current methods of fish farming today, develop tailor-made solutions driven by focused thinking and develop a holistic approach of the fish farming cycle. Innovative solutions are implemented and validated through continuous data analysis, thus setting premium larval quality standards to enhance fish farming performance.

based on generating sound scientific knowledge to further improve protocols and create solutions to the current bottlenecks in producing better quality fry and fingerlings rather than solely focusing on increasing production quantities.

Launched in 2015, FRY 2.0 project is a voluntary collaborative agreement between producers and INVE, in which all participants agree to work together to achieve a common purpose (Fig. 2). Synergy and knowledge are the power behind this partnership where all parties will undertake specific tasks and share risks, responsibilities, resources, competencies and benefits. The main European fish farming players are already involved in the project, or at least have showed interest to join FRY 2.0, and acknowledge that this is a long-term customized project based on confidence, credibility and mutual benefits. Besides producers and INVE, several R&D centers are also involved in the FRY 2.0 project, namely the Hellenic Centre for Marine Research and the University of Crete from Greece, the Università della Tuscia from Italy, Ghent University from Belgium, and the FishVet Group from Norway. Through this project, INVE will implement customer's suggestions and will commit to the continuous improvement in fish quality measured at the farm gate.

References

[1] The EU Fish Market, 2018 Edition. Available at https://www.eumofa.eu/the-eu-fish-market

O'Connor CM, Norris DR, Crossin GT and Cooke SJ. (2014) Biological carryover effects: linking common concepts and mechanisms in ecology and evolution *Ecosphere, 5(3), 1– 11*.

Pechenik JA. (2006) Larval experience and latent effects - metamorphosis is not a new beginning. *Integrative and Comparative Biology 46:323-333*.

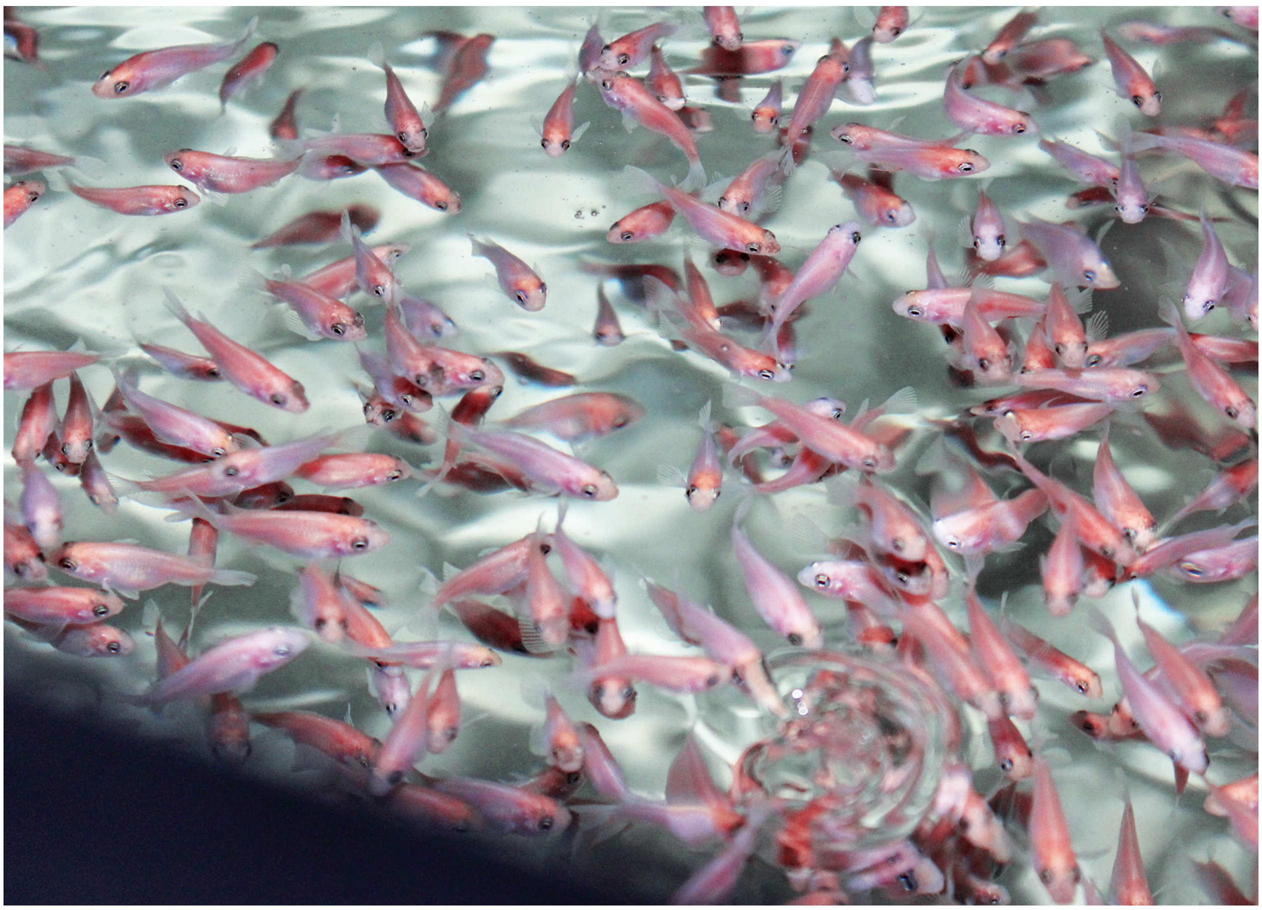
More information:

Alessandro Moretti
Product Manager
Fish Hatchery & Artemia
INVE Aquaculture, Benchmark's Advanced Nutrition Division
E: info@inveaquaculture.com

Promoting sustainable aquaculture in Eastern Africa by demonstrating innovative technologies

Kyra Hoevenaars & **Sam Clough,** VicInAqua project

Lake Victoria in Eastern Africa, the second largest freshwater lake in the world, is a very important resource for the surrounding countries, providing communities with water, food and employment. Fisheries is the most vital industry in the Lake Victoria Basin, being a major source of income for the population and an important part of the national economies in the region. However, the lake is under pressure due to overfishing and severe pollution. Promoting aquaculture in the region is now more important than ever and can provide livelihood opportunities and reduce environmental impact on the lake.



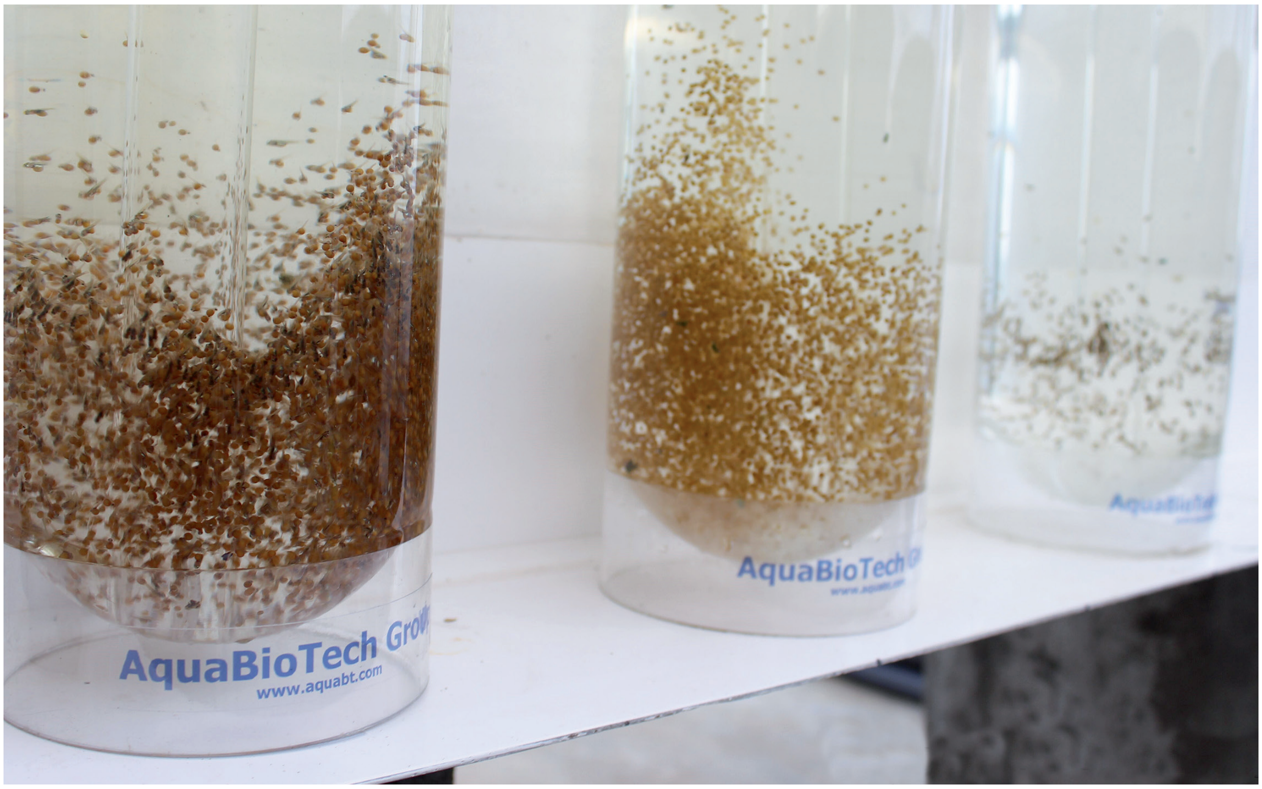
The VicInAqua hatchery produces fry for local fish farmers. © AquaBioTech Group

Visitors in the nursery system during the inauguration of the VicInAqua pilot. © AquaBioTech Group

Currently, the aquaculture sector in Kenya, Tanzania and Uganda mainly consists of small-scale farmers using earthen ponds to grow their fish. These are low labor, easily managed systems but can only sustain low stocking densities. Fish hatcheries in the basin use low level flow-through culture systems to ensure the high-water quality that is necessary for egg incubation and larval rearing.

The adoption of modern innovative technologies has contributed to the growth of aquaculture globally and, for the aquaculture sector around Lake Victoria to follow suit, practices and equipment developed elsewhere can be applied here. Recirculating Aquaculture Systems (RAS) incorporate water treatment and reuse 90-95% of the water. RAS offers a variety of important advantages compared to open pond culture, such as reduced water and land requirements, environmental control, year-round operation, waste management control, and food safety

The hatchery has a capacity to produce 25,000 fingerlings per month to supply pond aquaculture in the area. It is designed as a flexible, scalable and modular system which can be adapted to the needs of the operator.



Egg incubation jars with eggs and swim up fry in different stages. © AquaBioTech Group

This system was conceived to run as a green water RAS. The hatchery is located inside a greenhouse with high temperature, light levels and a high nutrient load in the water, due to the high stocking density of the fish, creating the ideal conditions for plankton growth.

benefits. However, around Lake Victoria only a handful of operators use a form of RAS for their fish culture.

VicInAqua RAS tilapia hatchery

VicInAqua, a project under the EU Horizon 2020 program gathering 11 partners from Eastern Africa and Europe, has developed a tilapia hatchery in Kisumu, Kenya that runs using RAS. The hatchery has a capacity to produce 25,000 fingerlings per month to supply pond aquaculture in the area. It is designed as a flexible, scalable and modular system which can be adapted to the needs of the operator. The hatchery was completed at the beginning of this year and the first fingerlings have been distributed to grow-out farmers. The project brings together multiple technologies from different sectors. Energy demands, often one of the largest overheads for any RAS system are met chiefly through renewable energy sources – solar and biogas located on site. This has a second advantage of reducing the systems dependence on a national grid which suffers from frequent outages. Monitoring of system parameters, using technology provided by project partner Oxyguard is available in real time online as well as on site, allowing problems to be identified quickly and site staff notified.

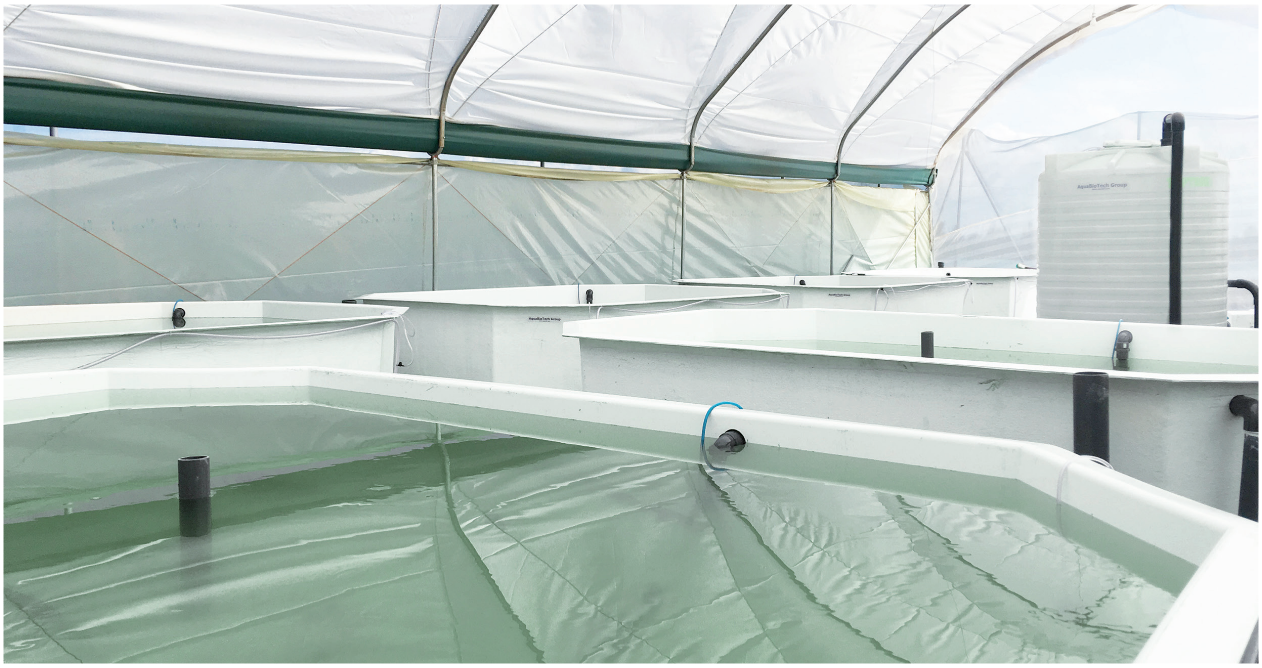
Finally, in regions such as this, potable water can be scarce and therefore costly. For the first time in the industry, the RAS was coupled to a Membrane BioReactor, a novel filtration system implemented by VicInAqua coordinator, the University of Applied

Sciences, Karlsruhe, and integrating novel coating and cleaning technologies developed by project partners ITM-CNR and University of Calabria, Italy. Raw sewage from local towns is treated using this equipment, and the RAS system is now fully operational running exclusively on this free supply of recovered water. Water quality tests show it is free of contaminants. Fish living in this water displayed no ill effects and comparisons of ammonia levels from before and after its use showed no difference - remaining consistent at 0 - 0.25 mg/L. The fish produced from the hatchery have been certified for human consumption. The success of this aspect of the pilot will hopefully encourage businesses to further invest in technologies such as these, reducing the reliance on limited water supplies and potentially allowing for RAS aquaculture to operate in areas which previously were not feasible.


Tilapia (*Oreochromis niloticus*) broodstock in the hatchery.
© AquaBioTech Group

Green water RAS

This system was conceived to run as a green water RAS. The hatchery is located inside a greenhouse with high temperature, light levels and a high nutrient load in the water, due to the high stocking density of the fish, creating the ideal conditions for plankton growth. Green water in this context has several advantages. Fish are less stressed than they are in clear tanks and juveniles can utilize the plankton bloom as feed.



Broodstock system that consists of 6 fiberglass tanks of $3m^3$ each. © AquaBioTech Group

While at this stage Feed Conversion Rate has not yet been measured, it is anticipated that it will be lower than in a clear system and growth rates in juvenile fish will be greater.

However, we found some issues particularly when the density of algae gets too high. Photosynthesis causes large daily variations in Dissolved Oxygen and pH levels, which makes managing fish stocks difficult. Biofilter activity is impacted by changes in pH, potentially influencing water quality. Drum filters are under more pressure and backwashing frequency increased. To control the algal load in the systems, maintaining it at advantageous levels, regular and rigorous cleaning and siphoning of tanks is required, shade netting was installed over the tanks and tank turnover was increased. Ultraviolet (UV) disinfection also had a notable affect in inhibiting algal growth.

The purpose of the project is to demonstrate the possible technologies in-situ, execute experiments and finally come up with a financially feasible upscaled design ready for the African market. The technology development and demonstration at pilot scale is combined with capacity building of local and regional actors. The hatchery is used by the local partner in Kisumu, the Department of Livestock, Agriculture and Fisheries, as a training and demonstration facility to promote the aquaculture sector and increase awareness, knowledge and skills for fish farmers in addition to selling fingerlings to the local cage farmers.

Acknowledgement

This research has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement number 689427 for the project VicInAqua.

More information:

Kyra Hoevenaars
Senior Aquaculture Consultant
AquaBioTech Group
E: kyh@aquabt.com

More information:

Sam S. Clough
RAS installations
AquaBioTech Group
E: ssc@aquabt.com

Developments in aquaculture

Prof. Dr. ir. Peter Bossier, Director of the Laboratory of Aquaculture & Artemia Reference Center, and Chairman of Aquaculture Ghent University

Aquaculture Ghent University

Biofilm: friend or foe

Bacteria colonize the most favorable ecological niche. In larviculture, bacteria come into the system with the incoming water, green algae, rotifers, Artemia and microdiets. Of course, regrowth in the tank is very important as well. Colony forming units (CFU) will increase. Although it is very useful to monitor what is going on in the water phase, we should realize that microbial biofilms are everywhere. Basically, microorganisms like to grow in biofilm, and biofilm-based aquaculture systems (such as ponds with bamboo sticks) display enhanced productivity. Biofilm will be formed on surfaces when nutrient concentration is low or high. Yet under low nutrient concentration in the water, the biofilm is the place to be, because exopolymers of the biofilm can be substrate, and nutrients (such as organic N or organic P) tend to concentrate in the biofilm.

Biofilms can be hard to remove, because their inhabitants have an increased resistance to disinfectants and antibiotics. The latter gives biofilms a bad reputation, as they can become a reservoir for pathogens once they have invaded the system. Yet most of the time we rely heavily on biofilm to keep the larval ecosystem running. The most obvious situation is a RAS-based larviculture system. In RAS, plenty of surface is offered for colonization. Heterotrophic bacteria, nitrifying bacteria and denitrifying bacteria can colonize a RAS system. All these bacteria have different ecological niches, which need to be present. The knowledge on how to engineer RAS is increasing. From a microbial point of view, the design will always need to be based on some ecological principles. To create ecological niches, it is necessary to establish ecological gradients such as gradients in surface loading. Heterotrophic bacteria grow faster than autotrophic (nitrifying) bacteria. In a biofilter, heterotrophic bacteria tend to outcompete autotrophic bacteria for space in the presence of a high organic surface loading. Therefore, in the absence of organics and presence of ammonium, autotrophs will have an advantage. It is obvious that the size of the RAS will depend on the overall organic loading (which can be manipulated/reduced by protein skimmers), but in view of the different ecological niches of heterotrophs and autotrophs, having biofilters in series might offer the necessary ecological niches to the different groups of bacteria. Oxygen gradients can also be interesting. At the top of a biofilm, oxygen concentration tends to be higher than at the bottom. With low oxygen and therefore low redox potential, denitrification becomes possible in a biofilm. In the future, increased microbial ecological insight will definitely help to improve the design of RAS systems. Just to give an example, the discovery of so-called commamox bacteria, able to single-handedly oxidize ammonium to nitrogen gas, raises the question on their preferred ecological niche.

RAS are designed to offer surface to bacteria outside the larval tank, but attempts have been made to offer them space inside the tank. By adding clay minerals, and hence surface, it has been demonstrated that the amount of bacteria in the water is being reduced and the scope for larval growth is increasing.

Finally, a single bacterium species or strain has many ‘faces’ (metabolic states). The planktonic state and sessile state are amongst the best described (viable but non-culturable, VBNC). A lot of metabolic activities change drastically when they switch. Sessile (biofilm) bacteria will produce exopolymers, but can also produce less virulence factors, become more resistant to antibiotics and are less motile. Luminescent Vibrio, for example, might stop to produce light in the sessile state. Hence offering ecological niches and establishing gradients might not only steer microbial communities and their composition, but also their activity. The latter might also depend on the capacity of some micro-organisms to perform phenotypic switches.

As long as we can keep pathogens out, biofilms are friends.

Industry Events

Send your meeting details to:
editor@hatcheryfeed.com

JUNE

17 – 18:	Aqua Fisheries Cambodia, Phnom Penh, Cambodia	aquafisheries-expo.com
18 – 21:	Asian Pacific Aquaculture, Chennai, India	was.org/APA2019

JULY

9 - 11:	Aqua Expo El Oro, Machala, Ecuador	aquaexpoeloro.cna-ecuador.com
18 – 21:	Applied Food and Feed Extrusion, Bangkok, Thailand	fie.com.au

AUGUST

14 - 15:	TARS 2019, Bali, Indonesia	tarsaquaculture.com
20 - 23:	Aqua Nor, Trondheim, Norway	aqua-nor.no
25 - 30:	26th Annual Practical Short Course on Aquaculture Feed, Texas, USA	perdc.tamu.edu

SEPTEMBER

10 - 11:	Aquaculture Innovation Europe, London, UK	aquaculture-innovation.com
26 - 28:	Aqua Fisheries Myanmar, Myanmar, Burma	aquafisheries-expo.com
26 - 28:	Intensive Shrimp Farming Technology, Singapore	aquaculturesg.org

OCTOBER

7 - 10:	Aquaculture Europe 2019	aquaeas.eu
21 - 24:	GOAL Conference 2019, Chennai, India	aquaculturealliance.org
31 - Nov 2:	Aquaculture Taiwan Expo & Forum, Taipei, Taiwan	aquaculturetaiwan.com

NOVEMBER

4 - 6:	Aquafeed Extrusion Technology, Temuco, Chile	fie.com.au
13 -15:	International Symposium on Aquaculture Nutrition, Yucatán, Mexico	sisal.unam.mx
19 - 22	Latin American & Caribbean Aquaculture 2019, San José, Costa Rica	was.org/lacqua19

DECEMBER

3 - 5:	AlgaEurope 2019 International Conference, Paris, France	algaeurope.org

HATCHERY MART

The virtual marketplace

COMPLETE FEED
BROODSTOCK

LIVE FEEDS - ALGAE

COMPLETE FEED
LARVAL

Marketplace **Directory**

Aliga
http://aliga.dk/

Alltech Coppens
www.alltechcoppens.com

Extru-Tech
www.extru-techinc.com

Inve
www.inveaquaculture.com

Lallemand
www.lallemandanimalnutrition.com

Megasupply
www.megasupplyUSA.com

ProChaete
www.prochaete.com

Reed Mariculture
www.reedmariculture.com

Skretting
www.skretting.com

Sparos Lda
http://sparos.pt

Tom Algae
http://www.tomalgae.com

Zeigler
www.zeiglerfeed.com

Let's get your products in Hatchery Mart
sales@aquafeed.com

Visit: hatcheryfeed.com to view online: links are live in digital editions.